OLIGOCENE PALEONTOLOGY AND PALEOECOLOGY OF WAITETE BAY, NORTHERN COROMANDEL PENINSULA

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Abstract. Thirty-nine macrofossil taxa are recorded from the late Oligocene (Duntroonian to mid Waitakian) Torehina Formation at Waitete Bay, northern Coromandel Peninsula. A rich fauna dominated by infaunal suspension-feeding bivalves occurs in 25-30 m of calcareous siltstone and fine sandstone in the middle of the formation. Also recorded from this unit are 42 species of foraminiferal microfossils (3-5% planktic forms) from three faunal samples. Both macro and microfossils indicate accumulation in a sheltered marine environment at deep inner shelf depths (20-50 m).

A low diversity macrofauna, containing a mixture of soft sediment and hard substrate dwelling forms, occurs in sandy flaggy limestone in the upper part of the Torehina Formation. This fauna is also inferred to have lived at deep inner shelf depths on a sandy seabed where patches of lithified bioclastic sandstone was developing.

These fossil-based paleoenvironmental assessments indicate that the Torehina Formation was deposited during an interval in which sea level was raised or the area subsided 80-90 m.

PREVIOUS WORK

The geology of northern Coromandel Peninsula, in the vicinity of Waitete Bay was mapped by Fraser and Adams (1907), Kear (1955) and Skinner (1976). As early as 1886, the best exposures of middle Cenozoic sediments on the Coromandel Peninsula had been discovered and described from this area by Alexander McKay (1886).

McKay (1897), Park (1897), Maclaren (1900) and Fraser and Adams (1907) recorded the essential elements of the meagre fossil fauna within the sequence - unidentified bryozoa and foraminifera, one species each of echinoid, crinoid and fish, four species of bivalve and two of gastropods. Hayward *et al.* (1990) recorded a fossil reef coral head found within the sequence at Waitete Bay by Phil Moore. Eagle (1993) describes a new species of crinoid from the collections that we discuss in this paper. Fraser and Adams (1907) named the sequence Torehine Series and presented the first detailed description of the stratigraphy. Brothers and Mason (1954) presented stratigraphic columns for the sequence and Kear (1955) produced a detailed map of their distribution in the hills to the east.

The early workers thought the Torehina rocks to be early Eocene, but foraminiferal studies by Finlay and Hornibrook (in Brothers and Mason 1954, and Kear 1955) assigned them to a late Oligocene (Duntroonian or Duntroonian to Waitakian) age.

GEOLOGY (Fig. 1)

The northern end of the Coromandel Peninsula is essentially composed of Jurassic Manaia Hill Group greywacke basement overlain and intruded by Miocene and Pliocene Coromandel and Whitianga Group calc-alkaline volcanic and plutonic rocks (Skinner 1976). In several places, small outcrops of middle Tertiary sedimentary rocks are preserved between the Mesozoic basement and overlying Neogene volcanics. Two of these outcrops are early Miocene Colville Formation sequences that immediately predate the start of volcanism (Skinner 1969). The remaining outcrops are of thin late Oligocene Torehina Formation sequences (Kear 1955, Skinner 1976). The thickest and best exposed Oligocene outcrops occur in coastal exposures at Waitete Bay and in inland exposures in the adjacent hills to the east (Fig. 1).

In this paper, we focus on the paleontology of two Torehina Formation outcrop blocks - one exposed in the cliffs and banks around Waitete Bay (S10/289010) and the other exposed in recent road cuttings on the Coromandel-Colville Road half-way up the hill east of Waitete Bay (T10/301006). Measured stratigraphic columns for the section in each outcrop block are given in Fig. 1.

Both outcrop blocks have similar sequences, with an irregular greywacke surface overlain by:
(a) 0-12 m or more of massive to weakly stratified sandy, clast-supported, cobbly, pebbly, greywacke conglomerate with occasional fossil log moulds. Lenses and stringers of laminated fine to coarse, carbonaceous sandstone occur sporadically throughout the conglomerate unit, together with irregular, thin lignite laminae.

In the road cuttings this conglomerate unit passes conformably up into:
(b) 25-30 m of massive to weakly bedded, calcareous siltstone and muddy very fine sandstone. This unit is slightly carbonaceous in its lower parts and has several slightly sandier horizons containing common turritellid gastropods, large oysters and sporadic concretions around the fossils or sometimes around burrow systems.

In the Waitete Bay coastal exposures the siltstone unit is conformably overlain by:
(c) 7 m of massive to flaggy, weakly bedded, fine to medium sandy limestone, with a distinctive, 2 m thick, fossil-rich horizon of flaggy limestone 2 m above its base.

The top of the sequence has probably been removed by erosion as there is an unconformity and time gap between the Torehina Formation and the overlying Coromandel Group terrestrial volcanic rocks.

In this paper, we provide the first updated list of the macrofauna since Fraser and Adams (1907), a foraminiferal species list, and the first interpretation of the paleoenvironment as provided by the fossil faunas.

Fossil Record Numbers are those of the New Zealand Fossil Record File (prefixed by S10/f or T10/f). All macrofossils (except the coral head) are held in the collections of Auckland Institute and Museum and all microfossils are held by the Institute of Geological and Nuclear Sciences, Lower Hutt.

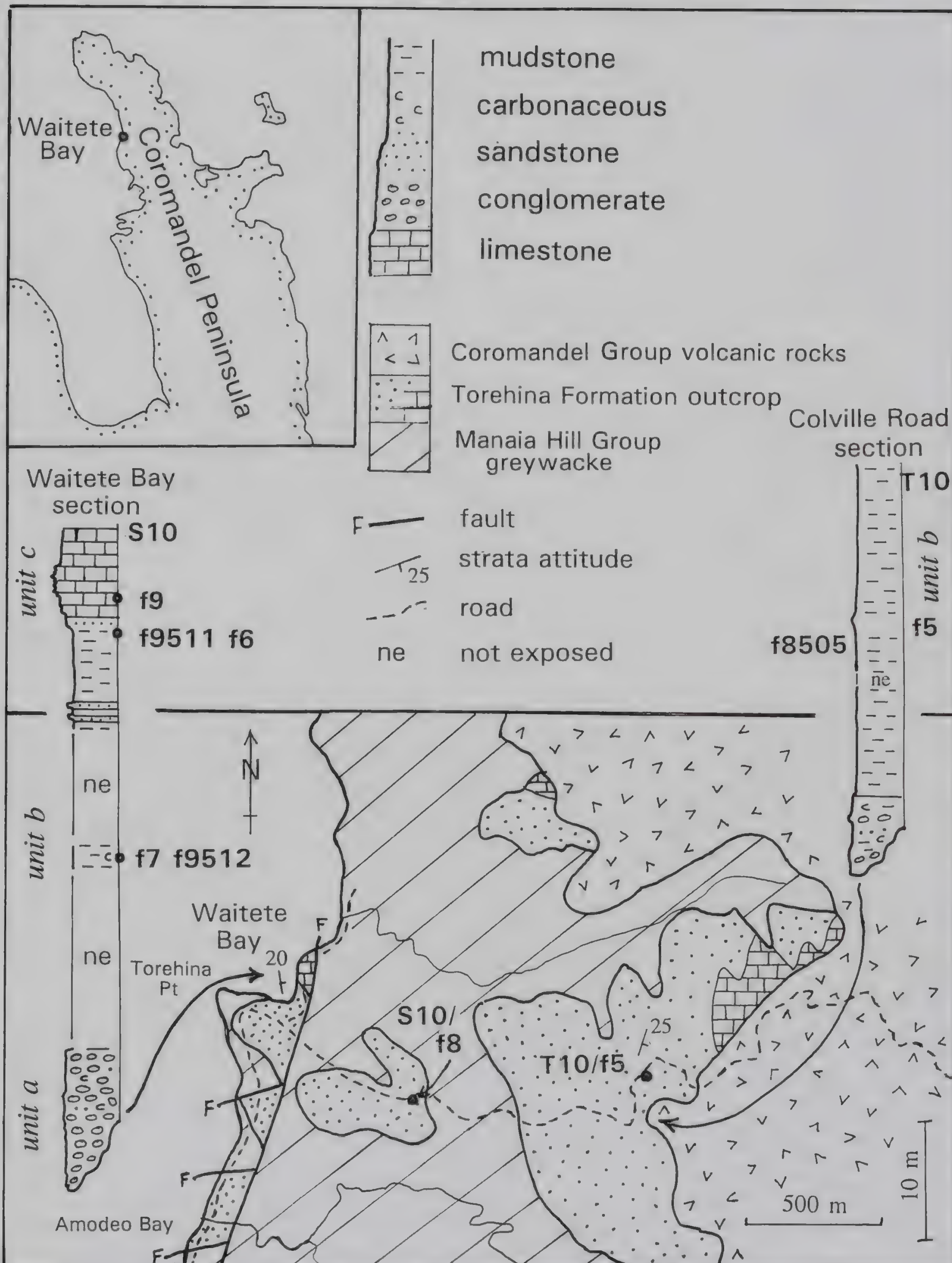

Fig. 1. Geological map of the Waitete Bay area of northern Coromandel Peninsula, after Kear (1955) and Skinner (1976), with stratigraphic columns for the Oligocene Torehina Formation at Waitete Bay and the Coromandel-Colville road section.

MACROFAUNA

All collected taxa are listed in Appendix 1. The paleontological and paleoenvironmental assessment that follows is largely based on the known ecology of genera living today and of modern species most closely related to these fossils.

INNER SHELF SILT AND SAND COMMUNITY, 10-50 m (Fig. 2)
S10/f6, S10/f7, S10/f8, T10/f5

The sparse fossil macrofauna collected from the calcareous siltstone unit at Waitete Bay and in Colville Road cuttings consists of decalcified, broken and disarticulated specimens.

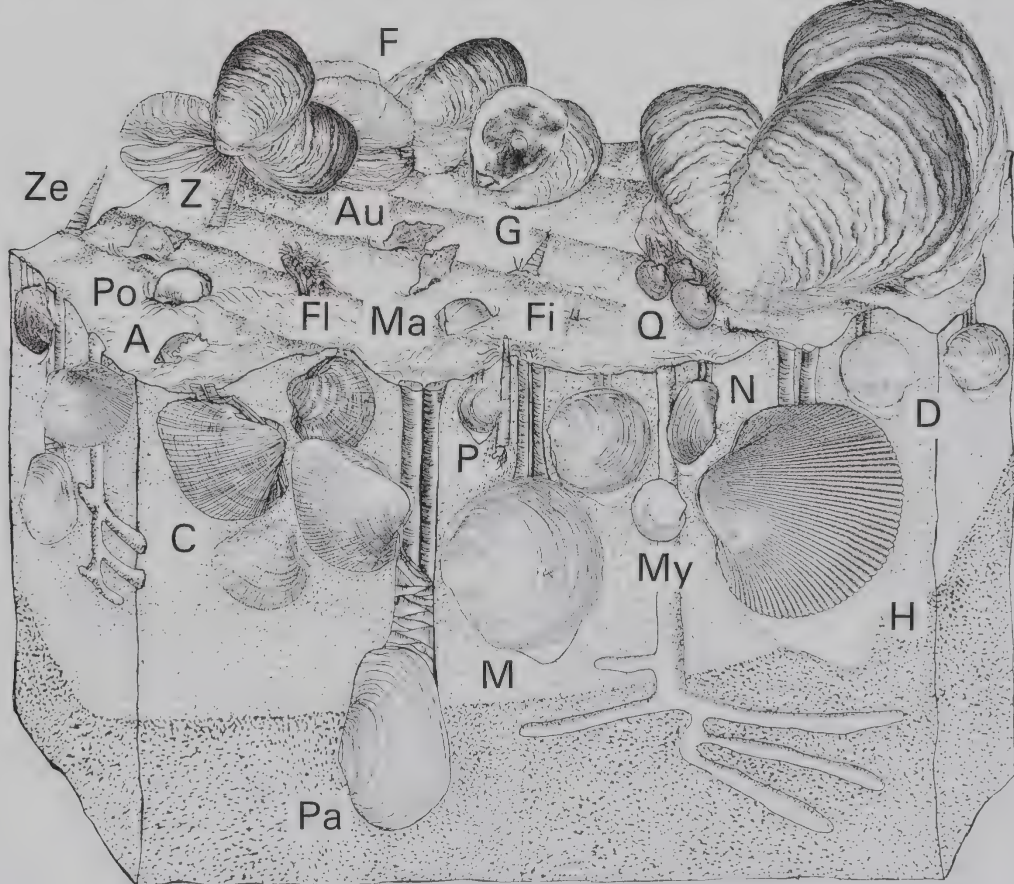

Fig. 2. Schematic drawing of the Waitete Bay *in-situ* Inner Shelf Silt and Sand Community (10-50 m). A= *Amalda (Baryspira)* cf. *pristina;* Au= *Austrofusus (Neocola) demissus;* C= *Cucullaea (Latiarca) worthingtoni;* D= *Dosinia (Austrodosinia) sodalis;* F= *Flemingostrea wollastoni;* Fi= *Fissidentalium solidum;* Fl= *Flabellum distinctum;* G= *Gazameda grindleyi;* H= *Hedecardium (Hedecardium) waitakiense;* M= *Miltha neozelanica;* Ma= *Magnatica (Magnatica) planispira;* My= *Myrtea staminifera;* N= *Neilo sinangula;* P= *Pteromyrtea auriculata;* Pa= *Panopea worthingtoni;* Po= *Polinices (Polinella) blaesus;* Q= *Quadrilatera* cf. *januaria;* Z= *Zeacolpus keari;* Ze= *Zeacolpus wharekuriensis.* No scale implied.

Decalcification of specimens is due to prolonged leaching and weathering. Minor pre-burial transport probably accounts for both breakage and disarticulation. The macrofauna occurs in silty, glauconitic horizons, veneered with rippled, fine-grained sand.

The depositional environment of this fossil assemblage is inferred to have been a sheltered bay with a paleo water depth of probably not more than 50 m. The biotope is interpreted as being below fairweather wave base, and above normal storm wave base, with fossils common in storm beds with parallel laminae or hummocky cross-stratification interbedded with fairweather fine-grained beds. The community lived epifaunally and infaunally in silt and fine glauconitic sand with the underlying Mesozoic bedrock providing the occasional, isolated, natural holdfast.

Like many Cenozoic fossil communities, it was dominated numerically by shallow-burrowing, suspension-feeding bivalves such as the most abundant fossil in this biotope, *Dosinia sodalis.* An important element was the large lucinid bivalve *Miltha neozelanica* which typically inhabited shellbeds in soft shallow marine substrates such as this. The smaller, more fragile bivalves *Myrtea* and *Pteromyrtea* are also present, as is the large, heavy *Cucullaea worthingtoni* which lacked a bysuss and lived freely in the silt and sand.

The epifaunal arcoid bivalve *Quadrilatera* cf. *januaria* probably preferred a hard substrate such as dead mollusc shells or greywacke rocks for byssal attachment. Also present was the deep burrower, the long-siphonate and sedentary, suspension-feeding *Panopea worthingtoni.* Like the living species *P. zelandica* (Morton and Miller 1968) this precursor probably burrowed 0.7 m or more into the soft sand.

The presence of the deposit feeder *Neilo sinangula* is suggestive of quieter water in the deeper parts of the inner shelf (>30 m), as living *Neilo* does not occur in the shallows. Another deposit feeding bivalve in this community was the large endemic *Hedecardium waitakiense* with its inflated thin shell.

Also common are specimens of the large oyster *Flemingostrea wollastoni.* This giant of its family almost certainly attached itself flat against exposed rock, or they lightly "welded" themselves to each other in well-oriented clusters, raised above the level of the silty seafloor. Many of these fossil oyster shells are bored by worms and sponges, indicating that these organisms were also active in this paleoenvironment. The head of a hermatypic coral *Leptastrea* is inferred to have been one of many scattered heads growing on the seafloor among the giant oysters.

Of the fossil gastropods present, the deposit-feeding turritellids *Gazameda grindleyi, Zeacolpus keari* and *Zeacolpus wharekuriensis* are common and probably lived on wide, sandy expanses at these inner shelf depths. Also ranging this open and exposed environment were the naticids *Magnatica planispira* and *Polinices blaesus.* Like their carnivorous descendents, both probably preyed upon burrowing bivalves.

Other minor members of this community were the infaunal scaphopod *Fissidentalium* and the ahermatypic coral, *Flabellum distinctum,* which probably attached itself to dead shells or nestled in the soft sediment. Several calcite tubes attest to the presence of the serpulid *Protula.*

Bioturbation and trace fossils are prevalent, indicating that a far greater variety of soft-bodied organisms lived in this community than fossil preservation provides evidence for.

INNER SHELF BIOCLASTIC SAND LITHOHERM COMMUNITY, 10-50 m (Fig. 3) S10/f9

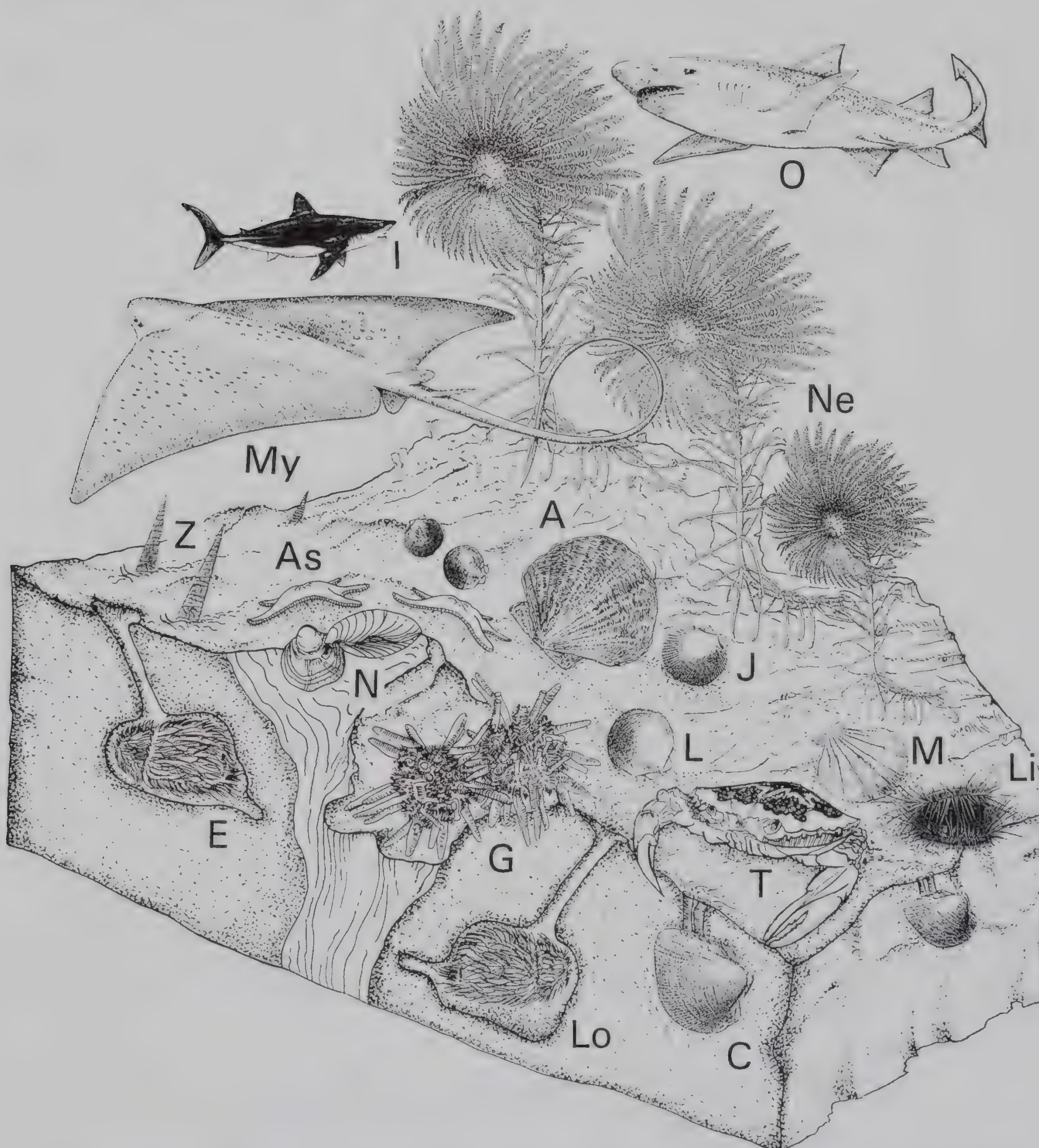

Fig. 3. Schematic drawing of the Waitete Bay *in-situ* Inner Shelf Bioclastic Sand and Lithoherm Community (10-50 m). A= *Althlopecten athleta;* As= asteroid sp.; C= *Cucullaea (Latiarca) worthingtoni;* E= *Eupatagus rostratus zitteli;* G= *Goniocidaris hebe;* I= *Isurus hastalis;* J= *Janupecten uttleyi;* L= *Lentipecten hochstetteri;* Li= *Lima paleata;* Lo= *Lovenia tuberculata;* M= *Mesopeplum burnetti;* My= *Myliobatis plicatilis;* N= *Neothyris* cf. *novara;* Ne= *Nielsenicrinus waiteteensis*; O= *Odontaspis elegans;* T= *Tumidocarcinus* cf. *tumidus;* Z= *Zeacolpus* sp. No scale implied.

A low diversity fossil macrofauna occurs in the sandy flaggy limestone at Waitete Bay. It is a mixture of mollusc, echinoderm, brachiopod, crab and shark remains. Some elements of the fauna would have lived in a soft sandy substrate and others require a hard substrate or crevices as a habitat. As no greywacke pebbles have been found in the limestone here, we suggest that a greywacke rock outcrop nearby is less likely than the development on the sea-floor of patches of lithified bioclastic sandstone (=lithoherm) surrounded by unlithified sand.

The bivalve *Cucullaea worthingtoni* and gastropod *Zeacolpus keari* probably inhabited the sandy areas of this community. There are four pectenid bivalves present: the large free-swimming, *Athlopecten athleta;* the smooth-shelled *Lentipecten hochstetteri;* the discordantly-sculptured, sessile *Janupecten uttleyi*; and the most common species, the strongly costate *Mesopeplum burnetti.* They would have lived on both the lithified and unlithified substrates. Another freely mobile bivalve present is *Lima paleata,* which was probably able both to swim and crawl, like the modern New Zealand *Lima colorata zelandica.*

Brachiopods were also part of this community. The radially ribbed *Magasella* cf. *sanguinea* and smooth valved, globular, *Neothyris* cf. *novara* would have attached by pedicle to any dead shell, exposed rock or pebble. Echinoderms are represented by spatangoid and cidarid echinoids, an asteroid, and an isocrinid crinoid. Two cosmopolitan spatangoid genera are represented: *Lovenia* and *Eupatagus.* They are characteristic infaunal dwellers, and probably dug themselves many centimetres into the soft substrate by the movement of their lateral spines.

Fossil interambulacral plates show that the cosmopolitan, cidarid *Goniocidaris* existed in this community. It probably lived nestled in cracks, under ledges or in cavities in the lithoherm, as does the recent New Zealand *G. umbraculum.* Starfish are natural prehensile predators of bivalves. It is not surprising then that a large starfish (asteroid) ossicle should be found in an environment populated by pectenids.

Nielsenicrinus waiteteensis is a typical semi-sessile, benthic isocrinid which probably lived attached to the lithoherm where weak currents provided both food and oxygen to the passive filter-feeders. Although crinoids are extremely rare at inner shelf depths, much of the rest of the fossil fauna is indicative of inner shelf depths of 10-50 m.

A chela of the crab *Tumidocarcinus* cf. *tumidus* is the only evidence of any crustacea. The crab probably resided in narrow crevices or beneath stones, feeding on worms, isopods, amphipods and some molluscs. Scattered evidence of the necktonic fauna that swam freely overhead is provided by several fossil teeth of the lamnid sand sharks *Odontaspis elegans* and *Isurus hastalis* and by a partial crushing plate of the eagle ray, *Myliobatis plicatilis.* The fauna described above probably lived amongst hydroids, seaweeds, annelids, sponges and tunicates, none of which is usually fossilised.

RARE OR UNUSAL TAXA

The Waitete Bay fossil fauna contains the rare bivalve *Miltha neozelanica.* This large extinct mollusc is a cosmopolitan taxon characteristic of a shallow, nearshore, soft substrate (Beu *et al.* 1990). Another bivalve, the byssally-attached, endemic, warm-water arcoid *Quadrilatera januaria* has been recorded from late Eocene to middle Oligocene (Kaiatan to

Whaingaroan stages) rocks, mainly at South Island localities. Two poor specimens referrable to this species were found in late Oligocene rocks at Waitete Bay. This range extension may be due to preferred paleoenvironmental conditions.

The head of the coral *Leptastrea* is to date the only record of hermatypic (reef-building) corals in the New Zealand Oligocene (Hayward *et al.* 1990). Numerous coral heads and pieces, but no reefs, are known from the slightly younger early Miocene of northern New Zealand (Hayward 1977a). It is unusual to find crinoids in such shallow, inner shelf depths today or in the Tertiary. Thus the presence in this rich deposit of fossil remains of a new isocrinid species *Nielsenicrinus waiteteensis* (Eagle 1993) is of considerable interest. Crinoids disarticulate readily at death and are often transported some distance with resulting abrasion making the skeletal remains unidentifiable. To recover identifiable crinoid components *insitu* as at Waitete Bay is also unusual. The partial mouth crushing plate of an eagle ray is a rare find.

MICROFAUNA

Of nine sediment samples taken from the Torehina Formation and processed for foraminiferal microfaunas over the last 45 years, three were found to contain rich, moderately preserved faunas. Two samples come from the bottom (S10/f9512) and the top (S10/f9511) of the calcareous siltstone unit at Waitete Bay and the third sample (T10/f8505) from the middle of the siltstone in the Coromandel to Colville Road section (Fig. 1). Several other more sparse and poorly preserved microfaunas had essentially similar composition to the three rich faunas. No foraminiferal microfaunas have been obtained from the carbonaceous conglomerate unit nor from the extremely hard, cemented limestone unit. The three rich microfaunas were repicked, fully identified and percentage abundance estimates were obtained for planktics and the different benthic species (Appendix 2).

In all three samples, planktics comprise only 3-5% of the foraminifera, a character suggestive of neritic water conditions most usually in a sheltered environment at inner shelf depths (Hayward 1986).

The benthic faunas are dominated by a combination of *Notorotalia spinosa*, *Arenodosaria antipoda*, *Cibicides* spp., *Melonis* spp. and *Gyroidina allani* with a number of less abundant species. This combination of dominant species is considered to be characteristic of sheltered, muddy, inner shelf depths in the Oligocene and late Eocene around New Zealand (Hayward 1986). The fauna lacks any restricted deeper water taxa, but also none or very few of the taxa that usually dominate beach and high energy subtidal (0-20 m depth) environments of this age, such as *Cibicides notocenicus*, glabratellids, miliolids, discorbids, *Amphistegina* and *Elphidium*. The microfaunas are essentially the same as assemblage (b) from the late Eocene and Oligocene of Northland (Hayward 1985), which would have lived in a low energy, sheltered, muddy environment at deeper inner shelf depths (20-50 m).

AGE

MACROFAUNAL EVIDENCE

The presence of the molluscs *Janupecten uttleyi* (Ar-Ld), *Athlopecten athleta* (Ld-Lw), *Magnatica (Magnatica) planispira* (Ld-Pl), *Gazameda grindleyi* (Ld-Lw), the cidarid

Goniocidaris hebe (Ld-Pl) and the crab *Tumidocarcinus* cf. *tumidus* (Lwh-Ld) in the Waitete Bay fauna gives a late Oligocene (Duntroonian, Ld) age. This record of the arcoid genus *Quadrilatera* extends its time range beyond the Whaingaroan into the Duntroonian.

MICROFAUNAL EVIDENCE

There are few age-diagnostic foraminifera present in these Torehina Formation samples. The presence of *Notorotalia spinosa* (Ld-Pl) and *Globigerina euapertura* (Lwh-mLw) give a definite late Oligocene age (Duntroonian to middle Waitakian, Ld-mLw). One specimen of *Rectuvigerina* intermediate between *R. rerensis* (Lw-Sc) and *R. striatissima* (Lwh-Ld) suggests that the age may be close to the Duntroonian-Waitakian boundary.

When combined, the macrofaunal and microfaunal evidence support a late Oligocene, Duntroonian age.

PALEOENVIRONMENT AND PALEOGEOGRAPHY

No marine macro or microfossils have been found in the basal conglomerate (unit a, Fig. 1). It appears to have a non-marine fluvial or alluvial origin. All the microfaunas and most of the macrofauna have been recovered from the calcareous siltstone and fine sandstone (unit b) that overlies the conglomerate. There is no observable change in the fossil content throughout the 25-30 m thickness of this unit. The macrofauna and foraminiferal microfaunas together support an inferred sheltered environment at deep inner shelf depths (20-50 m). The presence of some areas of solid greywacke rock nearby is inferred from the macrofauna.

The overlying sandy limestone (unit c) contains a low diversity macrofauna in its lower parts that indicates continued inner shelf depths. Some elements of the fauna would have lived on a hard substrate or within cracks and crevices within it. We infer the development of a patchwork of lithified bioclastic sandstone on the seafloor at this time.

The approximately 50 m thickness of this Torehina Formation sedimentary sequence documents an interval of raised sea level or slow subsidence in the late Oligocene of the northern Coromandel. Paleo water depths do not appear to have exceeded 50 m and thus the amount of raised sea level or subsidence is unlikely to have exceeded 100 m (accounting for the accumulation of 50 m of sediment) and may have been closer to 80-90 m.

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APPENDIX 1. Systematic list of macrofauna tabulated from the Waitete Bay inner shelf silt and sand community (S) and inner shelf bioclastic sand and lithoherm community (L) localities. Taxonomy follows Beu *et al.* (1990) for mollusca; Dawson (1990) for brachiopods; Foster (1978) and Buckeridge (1983) for barnacles; Chapman (1918) and Vickers-Rich *et al.* (1991) for chondrichthyans; Henderson (1975) for spatangoid echinoids; Fell (1954) for cidarids; Feldmann and Keyes (1992) for decapod crustacea; Fleming (1971) and Hayward (1977b) for polychaeta; and Squires (1958, 1962) for corals.

S = SILTSTONE AND FINE SANDSTONE UNIT
S10/f6 Waitete Bay, north end, beneath limestone, S10/289010
S10/f7 Waitete Bay, south end, at stream mouth, S10/288009
S10/f8 Colville Road, 800 m up from Torehina Point, S10/296006
T10/f5 Colville Road, 1.3 km up from Torehina Point, T10/302007

L = LIMESTONE UNIT
S10/f9 Waitete Bay, north end, S10/289010

MOLLUSCA
BIVALVIA

MALLETIIDAE	*Neilo sinangula* Finlay, 1926	S
NOETIIDAE	*Quadrilatera* cf. *januaria* (Marwick, 1926)	S
CUCULLAEIDAE	*Cucullaea (Latiarca) worthingtoni* Hutton, 1873	S
PECTENIDAE	*Athlopecten athleta* (Zittel, 1864)	L
	Janupecten uttleyi (Marwick, 1924)	L
	Lentipecten hochstetteri (Zittel, 1864)	L
	Mesopeplum burnetti (Zittel, 1864)	L
LIMIDAE	*Lima paleata* Hutton, 1873	L
OSTREIDAE	*Flemingostrea wollastoni* (Finlay, 1927)	S
LUCINDAE	*Miltha neozelanica* Marshall & Murdoch, 1921	S
	Myrtea staminifera (Marwick, 1929)	S
	Pteromyrtea auriculata (Bartrum, 1919)	S
CARDIIDAE	*Hedecardium (Hedecardium) waitakiense* (Suter, 1907)	S
	Dosinia (Austrodosinia) sodalis Marwick, 1929	S
HIATELLIDAE	*Panopea worthingtoni* Hutton, 1873	S

GASTROPODA

TURRITELLIDAE	*Gazameda grindleyi* (Marwick, 1971)	S
	Zeacolpus keari Marwick, 1971	S
	Zeacolpus wharekuriensis Marwick, 1971	S
NATICIDAE	*Magnatica (Magnatica) planispira* (Suter, 1917)	S
	Polinices (Polinella) blaesus Marwick, 1929	S
OLIVIDAE	*Amalda (Baryspira)* cf. *pristina* (Olson, 1956)	S
BUCCINIDAE	*Austrofusus (Neocola) demissus* Marwick, 1931	S

SCAPHOPODA

DENTALIIDAE	*Fissidentalium solidum* (Hutton, 1873)	S

	BRACHIOPODA	
DALLINIDAE	*Magasella* cf. *sanguinea* (Leach, 1814)	L
	Neothyris cf. *novara* (von Ihering, 1903)	L
	ECHINODERMATA ASTEROIDEA	
	ossicle, gen. et sp. indet.	L
	ECHINOIDEA	
CIDARIDAE	*Goniocidaris hebe* Fell, 1954	L
	SPATANGOIDEA	
LOVENIIDAE	*Lovenia tuberculata* (Zittel, 1864)	L
BRISSIDAE	*Eupatagus rostratus zitteli* Henderson, 1975	L
	CRINOIDEA	
ISOCRINIDAE	*Nielsenicrinus waiteteensis* Eagle, 1993	L
	CHONDRICHTHYES	
LAMNIDAE	*Isurus hastalis* Agassiz, 1843	L
	Odontaspis elegans Agassiz, 1843	L
MYLIOBATIDAE	*Myliobatis plicatilis* Davis, 1888	L
	CRUSTACEA DECAPODA	
XANTHIDAE	*Tumidocarcinus* cf. *tumidus* (Woodward, 1876)	L
	CIRRIPEDIA	
ARCHAEOBALANIDAE	*Tasmanobalanus acutus* (Withers, 1924)	L
	POLYCHAETA	
SERPULIDE	*Protula* cf. *tubularia* (Montagu, 1803)	S
	COELENTERATA	
FLABELLIDAE	*Flabellum distinctum* Milne-Edwards & Haime, 1848	S
FAVIIDAE	*Leptastrea* sp.	S
	BRYOZOA	
	gen. et sp. indet.	L

APPENDIX 2. List of foraminifera obtained from northern Coromandel Peninsula Oligocene samples. Numbers are abundances (%) in each sample (1-3). Asterisk signifies present but not recorded in quantitative pick. Taxonomy follows Hornibrook *et al.* (1989).

1 S10/f9512 Waitete Bay, S10/288009
2 S10/f9511 Waitete Bay, S10/289010
3 T10/f8505 Coromandel-Colville Road, T10/301006

	1	2	3
Benthics:			
Amphistegina sp.			3
Anomalinoides awamoana			*
Anomalinoides subnonionoides			1
Arenodosaria antipoda	23	5	15
Astrononion parki			*
Bulimina pupula	3		6
Cancris lateralis			1
Cibicides maculosa	5		
Cibicides perforatus			1
Cibicides temperatus		25	7
Cribrorotalia dorreeni	1		
Cribrorotalia longwoodensis			*
Cyclammina incisa			1
Dentalina obliquecostata	1		
Dentalina soluta			1
Discorbis scopos	3		9
Dorothia minima	3		
Elphidium gibsoni			*
Globocassidulina pseudocrassa			1
Globocassidulina subglobosa	1		
Guttulina fissurata	3		9
Gyroidina allani	12		17
Gyroidina prominula			2
Gyroidina subzelandica			1
Haplophragmoides sp.			*
Haeuslerella textilariformis	1		
Lenticulina loculosa	3		3
Marginulinopsis allani	6		*
Melonis dorreeni	3		
Melonis maoricum	3		4
Melonis simplex		25	
Notorotalia spinosa	22	35	12
Pararotalia mackayi	1		
Pseudopolymorphina parri			*
Pullenia quinqueloba	1		
Rectuvigerina rerensis x *striatissima*		1	
Saracenaria arcuatula	1		
Semivulvulina waitakia	1		1
Sigmoidina sp.			*
Sphaeroidina bulloides	5		4
Planktics:			
Globigerina euapertura	3	5	2
Globigerina labiacrassata			1